ISSN:0971-1260
Vol-22-Issue-37-December -2019

Microwave cladding of Ni-based powder on Stainless Steel SS-316 L

Hitesh Vasudev[1] Chandan Kumar[2]

[1,2]*School of Mechanical Engineering, Lovely Professional University , Phagwara-144411-India*

Email ID: hitesh.24804@lpu.co.in

ABSTRACT

Stainless steel 316L was processed by using microwave and Nickel powder was deposited on the surface. The layer of 1mm was obtained after microwave cladding. Mechanical analysis include the hardness testing for the developed cladding. The hardness was measured on Vickers hardness tester at 200g load and for a dwell time of 10seconds. The microstructure characterisation was done for the analysis of the powder and the developed cladding. The powder of nickel showed the spherical morphology and particle size of the powder was found to be ±45 microns. The microstructure of the coating showed the well bonded powder to the substrate.

KEYWORDS *Nickel based alloy, Wear resistance and Microwave cladding.*

I.INTRODUCTION

Engineering applications include the components which are subjected to sliding and rubbing within the integral parts of the machinery and wear occurs due to this contact between machine elements[1-3]. The failure of the components due to wear leads to economical loss and further immediate replacement of parts is required for the continuous working of the applications especially the production lines in industries. To prevent the material from degradation and downtimes of the production lines, coating process is being used by the researchers to enhance the surface properties of the material. The techniques which have been used include Physical Vapour Technique (PVD), Chemical Vapour technique (CVD), Thermal Spray Coating (TSC) techniques and heat treatment[4-8]. These processes provide good wear resistance against the severe fragile conditions and decrease the wear rates of the engineering components. The sputtering process like CVD and PVD are very costly and does not facilitate the mobility where a coating can easily be done at the location of components such as welding process. Moreover these processes use gases for combustion process

ISSN:0971-1260
Vol-22-Issue-37-December -2019

and therefore not eco-friendly to the environment hence produces pollution and eventually not safe. Recent advancements in the coating techniques come up with a technique known as Microwave Processing of materials with the use of domestic applicator. In this process material to be deposited is taken in powder form and deposited on the surface of the substrate in the microwave applicator through the heat produced by the microwaves and finally powder get melted and makes bonding with the parent material. This process does not use any gas for combustion and therefore pollution free and very economical as compared to other coating techniques [9-11]. In addition to these advantages the procedure of microwave cladding is not complicated and it is safer to operate as the microwave which is used for the material processing is same as the microwaves used in commercial household. In the present research work Nickel based alloy was deposited on the stainless steel SS-316L substrate through microwave applicator and their surface properties were analysed.

II. EXPERIMENTAL PROCEDURE

In the present study, Stainless steel grade SS-316L was selected as a substrate material. The main reason for the selection of this material is its use in various engineering applications like medical, aeronautical and parts in marine structures. The material was in the form of sheet having thickness 5mm and the required size was obtained after cutting on Wire-cut EDM. The substrate size was taken as 15mm x 25mm x 5mm for SEM analysis and micro hardness whereas for wear test pins were taken of 8 mm in diameter with 25 mm length. Substrate was properly cleaned using acetone to ensure its surface free from any dust particles present on the surface before cladding process. The specimen required for hardness testing was properly polished to get the hardness measurements . This was to ensure the surface roughness of the specimen as it is very critical in case of hardness testing that the surface should be even so that the values obtained may resulted in precise values .On the other hand the pins were ground and polished before cladding process and pins top ends coated with powder of nickel . Composition of the substrate is shown in table 1. X-Ray Diffraction (XRD) of coating powder which indicated the presence of nickel as a major element in the coating powder as shown in Fig.1..

Table 1. Composition of Stainless Steel SS-316L

GRADE	**C**	**Si**	**Mn**	**S**	**P**	**Mo**	**Cr**	**N**	**Ni**	**Fe**
SS-316L	0.03	0.75	2.0	0.03	.045	3.0	18.0	0.10	14.0	Bal.

ISSN:0971-1260
Vol-22-Issue-37-December -2019

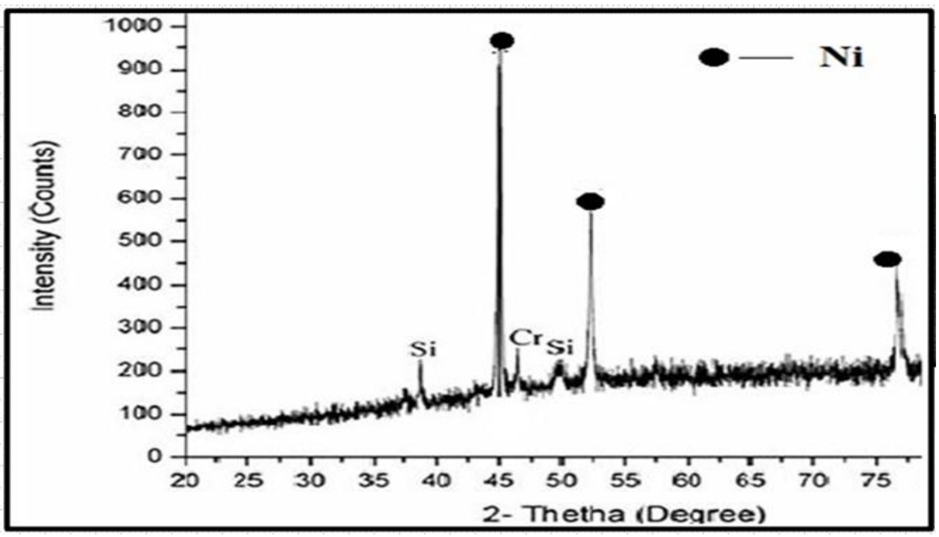

Fig.1. XRD image of Nickel based powder

III. COATING USING MICROWAVE APPLICATOR

Nickel based powder was deposited on the surface of the substrate using microwave and experiments were performed on applicator having 2.45 GHz frequency operated on power of 900W. For cladding of powder to the substrate powder was distributed on the substrate surface carefully and separator is placed over the powder and then suceptor was spread on the suceptor. Alumina plate of 1 mm thickness as a separator and charcoal powder as a suceptor was used as shown in Figure 2.

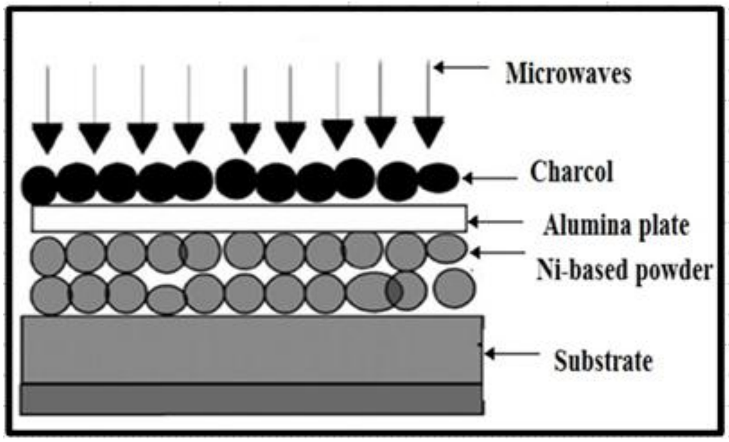

Fig.2. Microwave heating representation

The heat of the microwaves initially taken by the suceptor and then it transfers the heat to the ceramic plate separator and finally heat reaches to the powder where it melts the powder and powder gets deposited to the substrate. The various steps during deposition process of cladding and its effects are shown in table 2.

ISSN:0971-1260
Vol-22-Issue-37-December -2019

Table 2. Experiments performed for cladding with effects due to time exposure

Experiment	Time of exposure in minutes	Visual inspection of clad
1.		
2.	5	Without melting of powder
3.		
4.		
5.	10	Half melting
6.		
7.		
8.	15	Full melting of powder
9.		

Total nine experiments were performed to study the effect of time on the deposition process during microwave cladding .Three trails were made for the time interval of 5 minutes for the conformance of deposition process. It was observed that after exposure to first 5 minutes the powder remained unmelted and it got partially melted after 10 minutes and eventually the powder was completely melted after 15 minutes of exposure of time and it was properly bonded to the substrate.

IV.RESULTS AND ANALYSIS

IV. I MICRO HARDNESS ANALYSIS

A micro hardness test was performed for coated and uncoated substrates. Vickers hardness with load of 100g load for a dwell period of 10 seconds. The hardness of substrate was found to be 210 Hv and for the clad it was 405 Hv which is significantly high s compared to substrate as shown in figure3. The significant change obtained after cladding process is due to nickel powder particles which when diffuse into the substrate material that is Stainless steel SS-316L, it forms some hard compounds on the surface of the speciemens which enhanced the surface properties of the substrate and forms metallurgical bonding with the base metal. The process of cladding has a dominant factor in case of hardness due to this type of bonding which makes matrial hard as compared to the base material . In case of hardness test the indentations that were taken during measurements they showed almost values that are ver close to each other . This proper distribution of the coating powder on the surface

ISSN:0971-1260
Vol-22-Issue-37-December -2019

of the material also increased the wear resistance capacity of the cladded specimens which are repoted in the the section of sliding wear analysis.

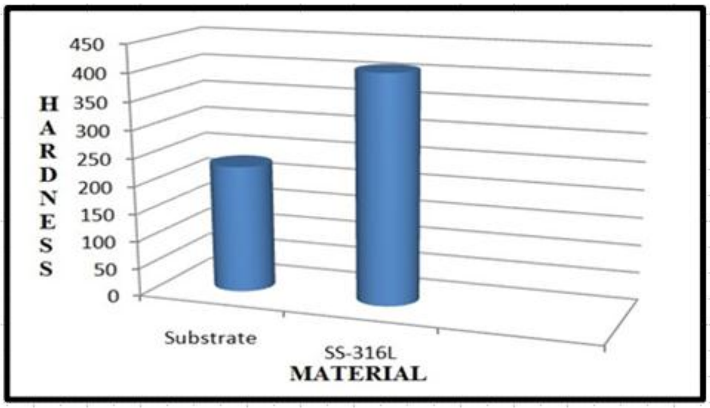

Fig.3. Micro hardness of substrate and cladded SS-316L

V. SLIDING WEAR STUDY ON PIN-ON DISC APPARATUS

Wear analysis was done using Pin-on disc test according to ASTM-G99 standard. Substrates having 10mm diameter and 30 mm length were selected for wear study. These substrates were initially ground and polished before wear testing. Weight loss was calculated for both coated and uncoated substrates after 6 intervals consisted of 90 minutes cycle. It was calculated from the weight loss analysis that cladded samples lost 0.2 grams material whereas the uncoated samples lost 0.8 grams material after complete cycle of 90 minutes. Therefore the cladding showed high wear resistance as compared to substrate.

VI. SEM ANALYSIS

It can be clearly seen from the SEM micrograph shown in figure 4 that the powder is well bonded to the substrate material and is free from any crack and semi melted particles. Proper bonding of the powder is due to the volumetric heating of the microwave cladding process and resulted in coating free from any pores and cracks. The average particle of the powder is 45 microns showing in figure .4 (a) and it is clearly seen in this figure that the shape of the coating powder is spherical.

ISSN:0971-1260
Vol-22-Issue-37-December -2019

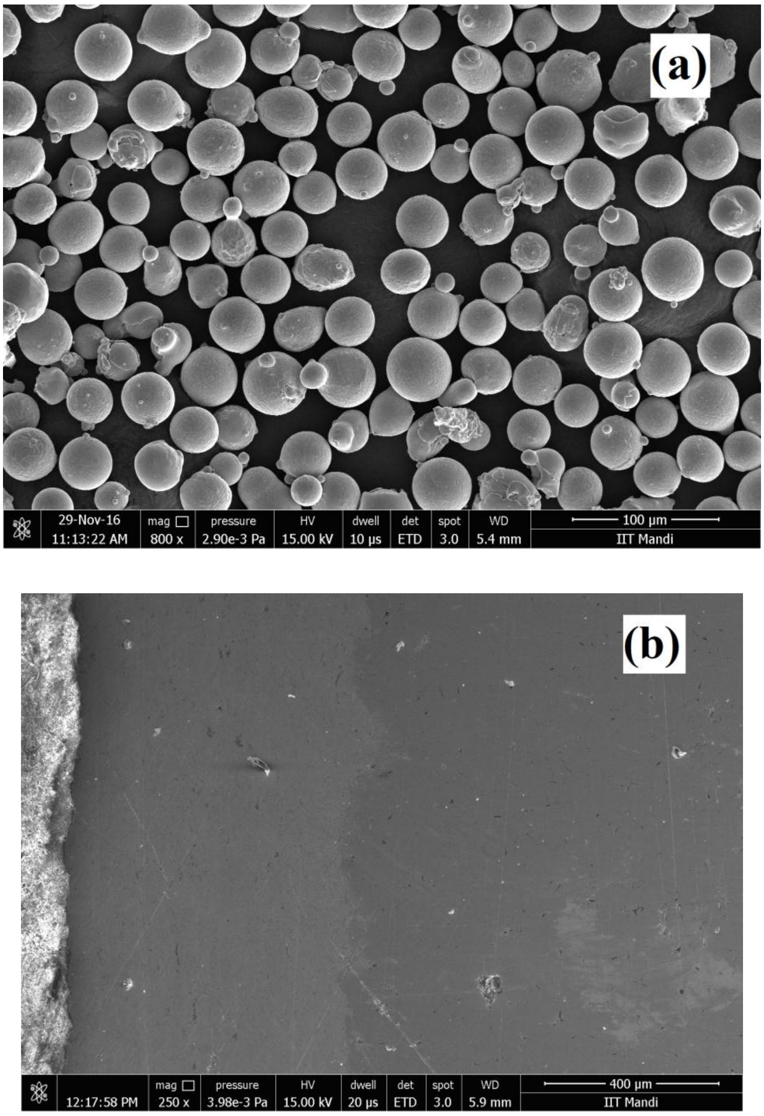

Fig.4 . SEM micrographs of Nickel alloy powder (a) and Cladded sample (b)

In figure 4(b) the substrate shows the clear bonding interface with clad formed on it and the planer structure showed no cracks formed at the interface and it is free from any kind of semi melted particles and pores which indicates no porosity present in the coating .

VII. CONCLUSIONS

1. The powder was successfully deposited using microwave route on Stainless Steel SS-316L.
2. Mechanical characterization by micro hardness showed significant increase in high hardness of 405Hv which resulted in less material loss in wear test.
3. Pin-on disc sliding wear test showed the less weight loss of cladded substrates hence improved wear resistance for Stainless steel SS-316L.
4. SEM micrographs showed well bonded interface and free from any semi melted particles and cracks.

ISSN:0971-1260
Vol-22-Issue-37-December -2019

REFERENCES

1. A. M. Hebbale and M. S. Srinath, "Microstructure and experimental design analysis of nickel based clad developed through microwave energy," Perspective Science, 2016.
2. D. E. Clark, D. C. Folz, and J. K. West, "Processing materials with microwave energy," Material science Engineering- A, vol. 287, no. 2, pp. 153–158, 2000.
3. D. Gupta and A. K. Sharma, "Development and microstructural characterization of microwave cladding on austenitic stainless steel," Surface Coatings Technology, vol. 205, no. 21–22, pp. 5147– 5155, 2011.
4. D. Gupta and A. K. Sharma, "Investigation on sliding wear performance of WC10Co2Ni cladding developed through microwave irradiation," Wear, vol. 271, no. 9–10, pp. 1642–1650, 2011.
5. E. T. Thostenson and T. Chou, "Microwave processing : fundamentals and applications," Composite Part A Applied Science Manufacuring, vol. 30, pp. 1055–1071, 1999.
6. K. Singh and S. Sharma, "Development of Ni-based and CeO 2 - modified coatings by microwave heating," Material Manufacturing Process, vol. 0, no. 0, pp. 1–8, 2016.
7. S. Harsha and D. K. Dwivedi, "Microstructure, hardness and abrasive wear behaviour of flame sprayed Co based alloy coating," Surface Engineering, vol. 23, no. 4, pp. 261–266, 2007.
8. S. Harsha, D. K. Dwivedi, and A. Agrawal, "Influence of WC addition in Co-Cr-W-Ni-C flame sprayed coatings on microstructure, microhardness and wear behaviour," Surface Coatings Technology, vol. 201, no. 12, pp. 5766–5775, 2007.
9. S. Singh, D. Gupta, V. Jain, and A. Sharma, "Microwave Processing of Materials and Applications in Manufacturing Industries: A Review," Material Manufacturing Process, no. December 2014, pp. 37–41, 2014.
10. S. Zafar and A. K. Sharma, "Development and characterisations of WC–12Co microwave clad," Material Characterizations, vol. 96, pp. 241– 248, 2014.
11. W. T. Preciado and C. E. N. Bohorquez, "Repair welding of polymer injection molds manufactured in AISI P20 and VP50IM steels," Journal of Material Process and Technology, vol. 179, no. 1–3, pp. 244– 250, 2006.
12. H.Vasudev , L.Thakur , H.Singh , A.Bansal : Mechanical and microstructural behaviour of wear resistant coatings on cast iron lathe machine beds and slides. Kovove Materialy, Metallic Materials ; 56(1):55-63,2018.
13. H.Vasudev , L.Thakur , A.Bansal , H.Singh and S.Zafar , "High temperature oxidation and erosion behaviour of HVOF sprayed Inconel-718 coating", Surface and Coatings Technology ,362 , pp.366-380,2019 .

ISSN:0971-1260
Vol-22-Issue-37-December -2019

14. H.Vasudev , L. Thakur , H.Singh , A review on tribo-corrosion of coatings in glass manufacturing industry and performance of coating techniques against high temperature corrosion and wear, i-Manager's J. Mater. Sci. 3,38-48,2017.
15. A.Bansal , H.Vasudev, A.K.Sharma and P.Kumar, Investigation on the effect of post weld heat treatment on microwave joining of the Alloy-718 weldment, Material research express,8,p1-15,2019.

